A Semi-Classical Description of the Shears Mechanism: The Role of Effective Interactions.†

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In the previous abstract we presented a semi-classical analysis of electromagnetic properties in the shears bands in ^{198,199}Pb. In what follows we study the nature of the effective interaction needed to reproduce a rotational-like spectrum. Knowing the angle θ between $\vec{j}_\pi$ and $\vec{j}_\nu$ and the level energies it is also possible to obtain information about this effective interaction, $V_{\pi\nu}$, between the protons and the neutrons[1]. For spatial forces we can expand in even multipoles as:

$$V_{\pi\nu}(\theta) = V_0 + V_2 P_2(\theta) + ... \qquad (1)$$

Let us now assume for simplicity that we have a neutron and a proton of the same j coupled to spin I and interacting via a term of the form $V_2 P_2(\theta)$. The energy along the band is given only by the change in potential energy due to the recoupling of the angular momenta and therefore

$$\Delta E(I) \propto V_2 \frac{(3cos^2\theta(I) - 1)}{2} \qquad (2)$$

In Fig. 1 we show the dependence of this term as a function of I and θ for the particle-particle (hole-hole) and particle-hole cases. As can be seen, the minimum of the potential energy for the particle-particle case occurs at $\theta = 180^0$, $I = 0$ where the overlap between the particle wave functions is maximum. Since for $I < j$ we have $sin\theta \approx (I/j)$, it follows from Eq. (2) that the low-spin members of the $(2j+1)$-multiplet are split approximately by I^2 as shown with the dashed curve. If we now turn our attention to the particle-hole channel, which is the situation in the Pb bands, the interaction changes sign and the minimum occurs at $\theta = 90^0$, $I_{90} = \sqrt{2}j$. We then obtain $\Delta E \propto (I - I_{90})^2$, as observed in experiment with I_{90} representing the spin of the bandhead. We note that the particle-particle or hole-hole channels can provide the basic coupling schemes for the so-called *Anti-magnetic Rotor* [2].

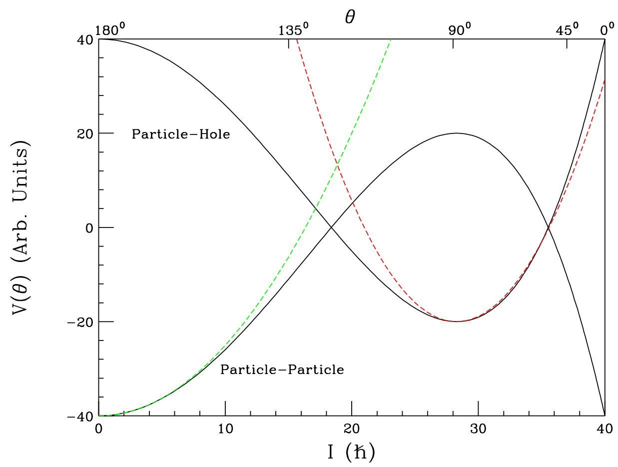

Figure 1: Particle-particle(hole) potential as a function of angular momentum and θ for an interaction of the form $V_2 P_2(\theta)$. The dashed lines correspond to a rotational approximation

The mass dependence of the moment of inertia, $\mathcal{J}$, of these M1 bands follows from Eq. (2). We have $\mathcal{J} \propto j^2/V_2$, and with the overall dependence $j \sim A^{1/3}$ and $V_2 \sim A^{-1}$ then $\mathcal{J} \sim A^{5/3}$ as in the case of normal rotational bands. Although the available information is still limited to a few examples that span a broad range of masses, they seem to confirm this prediction.

References

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